

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE
BEFORE THE BOARD OF PATENT APPEALS AND INTERFERENCES

Ex Parte PLOFSKY, Jordan

Application for Patent: 10/629,508

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Group Art Unit: 2114

Examiner: IQBAL, Nadeem

For:

EMBEDDED MICROPROCESSOR FOR INTEGRATED CIRCUIT TESTING
AND DEBUGGING

APPEAL BRIEF

Weaver Austin Villeneuve & Sampson LLP
P.O. Box 70250
Oakland, CA 94612-0250
Attorneys for Appellant

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1. REAL PARTY IN INTEREST

The real party in interest is Altera Corporation, 101 Innovation Drive, San Jose, California 95134.

2. RELATED APPEALS AND INTERFERENCES

There are no related appeals or interferences.

3. STATUS OF CLAIMS

The following claims have been rejected and appealed: claims 1-28.

The following claims have been cancelled: None.

The claims on appeal are reproduced below in the Appendix at Section 9 of this Appeal Brief.

4. STATUS OF AMENDMENTS

No amendments were filed subsequent to final rejection.

5. SUMMARY OF CLAIMED SUBJECT MATTER

5.1. Independent Claims 1, 7, 13

All of the independent claims and the claims dependent therefrom relate to diagnostic testing of a programmable logic device ("PLD").

Independent claim 1 summary and mapping to the Specification

Independent claim 1 specifically requires "a programmable logic device that comprises a hardcoded microprocessor in communication with programmable logic." In other words, the microprocessor is embedded inside the PLD.

The above mentioned limitations of the claim are shown in at least figures 1, 3, and 4. PLD 16 is shown as a part of system 10 in FIG. 1, and in greater detail in FIG. 3. FIG.3 illustrates that PLD 16 comprises memory 106, microprocessor 108, and programmable logic 104, all in communication with each other. PLD 16 is also shown with a testing or debugging board 200 in FIG. 4. FIG. 5 step 304 also

discloses a PLD with an embedded microprocessor and memory. The remainder of FIG. 5 discloses limitations of claims that depend from claim 1, which will not be discussed herein for the sake of brevity.

The above mentioned claim limitations are also described in the Summary of Invention in at least the following locations:

Page 3, lines 1-9. To achieve the foregoing, and in accordance with the purpose of the present invention, a technique for embedding a microprocessor into an integrated circuit is disclosed that allows on-chip testing and debugging. The present invention allows a circuit element present on the chip itself to test and debug the rest of the chip. Preferably this circuit element is a microprocessor which is capable of storing and executing instructions. The present invention is applicable for testing and debugging of integrated circuits and is especially useful with programmable devices because of the complexity and range of circuits requiring fault coverage.

Page 3, lines 17-19. With an embedded processor right on the chip, tests, patterns, simulation, etc., may be run right on the device. Because no communication is needed from the chip to the outside world for controlling the testing or debugging, the bottleneck of a serial interface is avoided.

Page 3, lines 20-23. In one embodiment for integrated circuit testing, an embedded microprocessor core is present in the PLD. Test costs are reduced and test coverage is increased, for example, by running through a regression that tests all hard function blocks and then reports status back through a JTAG port, SPI or other port.

Page 3, lines 24-30. In a second embodiment for debugging, an embedded microprocessor core in the PLD aids in the real-time debugging of the system at frequency. The embedded microprocessor is also useful for failure analysis probing of failed systems. Further, the embedded microprocessor can be used to improve the performance of gathering probe data during debugging. Further, the embedded microprocessor gives selective feedback by using enhanced compression techniques, adaptive selection of data based on known patterns and routines, and wider parallel output of data versus using a serial JTAG port interface.

The above mentioned claim limitations are also described in the Detailed Description in at least the following locations:

Page 8 lines 29 to page 9 line 12. FIG. 3 illustrates in greater detail the programmable logic device (PLD) 16 of FIG. 1. In addition to the usual programmable logic 104, PLD 16 includes hardcoded memory 106 and an embedded, hard coded microprocessor 108. Logic 104 may either be test logic that is programmed in by the manufacturer for purposes of testing the device, or may be user logic that is programmed by a design engineer for the purposes of constructing a device for use in a product. Memory 106 stores the code for running any test routines, or any code for a debugging simulator. Memory 106 may be any of a variety of types of memory such as SDRAM, DRAM or flash memory, although memory 106 is typically SRAM memory.

Microprocessor 108 may be any suitable microprocessor able to be embedded into a PLD. Preferably, microprocessor 108 is a standard-cell implementation of a processor, and may be a processor of any instruction set architecture or of any word size. The speed of the microprocessor and its performance may be varied depending upon the testing and debugging speeds necessary, while realizing that a higher performance microprocessor will be more expensive. Microprocessors such as Intel's Pentium, Motorola's Power PC, PMC's SB-1250, or the ARM 9 may be used. In one particular embodiment the NIOS microprocessor available from Altera Corporation is used.

The section entitled "FLOW DIAGRAMS" beginning on page 10, line 22, and ending at page 13, line 5 also describes the testing process, referring to processor 108 as the "embedded microprocessor" or "on-chip microprocessor"

Independent claim 7 summary and mapping to the Specification

Independent claim 7 recites "A programmable logic device (PLD) comprising ... a hard-coded microprocessor."

The above mentioned limitations of the claim are shown in at least figures 1, 3, and 4. PLD 16 is shown a part of system 10 in FIG. 1, and in greater detail in FIG. 3. FIG.3 illustrates that PLD 16 comprises memory 106, microprocessor 108, and programmable logic 104, all in communication with each other. PLD 16 is also shown with a testing or debugging board 200 in FIG. 4. FIG. 5 step 304 also discloses a PLD with an embedded microprocessor and memory.

The above mentioned claim limitations are also described in the Summary of Invention in at least the following locations:

Page 3, lines 1-9. To achieve the foregoing, and in accordance with the purpose of the present invention, a technique for

embedding a microprocessor into an integrated circuit is disclosed that allows on-chip testing and debugging. The present invention allows a circuit element present on the chip itself to test and debug the rest of the chip. Preferably this circuit element is a microprocessor which is capable of storing and executing instructions. The present invention is applicable for testing and debugging of integrated circuits and is especially useful with programmable devices because of the complexity and range of circuits requiring fault coverage.

Page 3, lines 17-19. With an embedded processor right on the chip, tests, patterns, simulation, etc., may be run right on the device. Because no communication is needed from the chip to the outside world for controlling the testing or debugging, the bottleneck of a serial interface is avoided.

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Page 3, lines 24-30. In a second embodiment for debugging, an embedded microprocessor core in the PLD aids in the real-time debugging of the system at frequency. The embedded microprocessor is also useful for failure analysis probing of failed systems. Further, the embedded microprocessor can be used to improve the performance of gathering probe data during debugging. Further, the embedded microprocessor gives selective feedback by using enhanced compression techniques, adaptive selection of data based on known patterns and routines, and wider parallel output of data versus using a serial JTAG port interface.

The above mentioned claim limitations are also described in the Detailed Description in at least the following locations:

Page 8 lines 29 to page 9 line 12. FIG. 3 illustrates in greater detail the programmable logic device (PLD) 16 of FIG. 1. In addition to the usual programmable logic 104, PLD 16 includes hardcoded memory 106 and an embedded, hard coded microprocessor 108. Logic 104 may either be test logic that is programmed in by the manufacturer for purposes of testing the device, or may be user logic that is programmed by a design engineer for the purposes of constructing a device for use in a product. Memory 106 stores the code for running any test

routines, or any code for a debugging simulator. Memory 106 may be any of a variety of types of memory such as SDRAM, DRAM or flash memory, although memory 106 is typically SRAM memory.

Microprocessor 108 may be any suitable microprocessor able to be embedded into a PLD. Preferably, microprocessor 108 is a standard-cell implementation of a processor, and may be a processor of any instruction set architecture or of any word size. The speed of the microprocessor and its performance may be varied depending upon the testing and debugging speeds necessary, while realizing that a higher performance microprocessor will be more expensive. Microprocessors such as Intel's Pentium, Motorola's Power PC, PMC's SB-1250, or the ARM 9 may be used. In one particular embodiment the NIOS microprocessor available from Altera Corporation is used.

The section entitled "FLOW DIAGRAMS" beginning on page 10, line 22, and ending at page 13, line 5 also describes the testing process, referring to processor 108 as the "embedded microprocessor" or "on-chip microprocessor"

Independent claim 13 summary and mapping to the Specification

Independent claim 13 specifically requires "manufacturing a PLD that includes programmable logic, an embedded microprocessor and associated memory."

The above mentioned limitations of the claim are shown in at least figures 1, 3, and 4. PLD 16 is shown a part of system 10 in FIG. 1, and in greater detail in FIG. 3. FIG.3 illustrates that PLD 16 comprises memory 106, microprocessor 108, and programmable logic 104, all in communication with each other. PLD 16 is also shown with a testing or debugging board 200 in FIG. 4. FIG. 5 step 304 also discloses a PLD with an embedded microprocessor and memory.

The above mentioned claim limitations are also described in the Summary of Invention in at least the following locations:

Page 3, lines 1-9. To achieve the foregoing, and in accordance with the purpose of the present invention, a technique for embedding a microprocessor into an integrated circuit is disclosed that allows on-chip testing and debugging. The present invention allows a circuit element present on the chip itself to test and debug the rest of the chip. Preferably this circuit element is a microprocessor which is capable of storing and executing instructions. The present invention is applicable for testing and debugging of integrated circuits and is

especially useful with programmable devices because of the complexity and range of circuits requiring fault coverage.

Page 3, lines 17-19. With an embedded processor right on the chip, tests, patterns, simulation, etc., may be run right on the device. Because no communication is needed from the chip to the outside world for controlling the testing or debugging, the bottleneck of a serial interface is avoided.

Page 3, lines 20-23. In one embodiment for integrated circuit testing, an embedded microprocessor core is present in the PLD. Test costs are reduced and test coverage is increased, for example, by running through a regression that tests all hard function blocks and then reports status back through a JTAG port, SPI or other port.

Page 3, lines 24-30. In a second embodiment for debugging, an embedded microprocessor core in the PLD aids in the real-time debugging of the system at frequency. The embedded microprocessor is also useful for failure analysis probing of failed systems. Further, the embedded microprocessor can be used to improve the performance of gathering probe data during debugging. Further, the embedded microprocessor gives selective feedback by using enhanced compression techniques, adaptive selection of data based on known patterns and routines, and wider parallel output of data versus using a serial JTAG port interface.

The above mentioned claim limitations are also described in the Detailed Description in at least the following locations:

Page 8 lines 29 to page 9 line 12. FIG. 3 illustrates in greater detail the programmable logic device (PLD) 16 of FIG. 1. In addition to the usual programmable logic 104, PLD 16 includes hardcoded memory 106 and an embedded, hard coded microprocessor 108. Logic 104 may either be test logic that is programmed in by the manufacturer for purposes of testing the device, or may be user logic that is programmed by a design engineer for the purposes of constructing a device for use in a product. Memory 106 stores the code for running any test routines, or any code for a debugging simulator. Memory 106 may be any of a variety of types of memory such as SDRAM, DRAM or flash memory, although memory 106 is typically SRAM memory.

Microprocessor 108 may be any suitable microprocessor able to be embedded into a PLD. Preferably, microprocessor 108 is a standard-cell implementation of a processor, and may be a

processor of any instruction set architecture or of any word size. The speed of the microprocessor and its performance may be varied depending upon the testing and debugging speeds necessary, while realizing that a higher performance microprocessor will be more expensive. Microprocessors such as Intel's Pentium, Motorola's Power PC, PMC's SB-1250, or the ARM 9 may be used. In one particular embodiment the NIOS microprocessor available from Altera Corporation is used.

The section entitled "FLOW DIAGRAMS" beginning on page 10, line 22, and ending at page 13, line 5 also describes the testing process, referring to processor 108 as the "embedded microprocessor" or "on-chip microprocessor"

5.2. Independent Claim 20

Independent claim 20 summary and mapping to the Specification

Independent claim 20 further requires "mounting in a test socket a PLD that includes user logic, an embedded microprocessor and associated memory."¹

This is described in the Detailed Description in at least the following locations:

Page 9 line 28 to page 10 line 6. FIG. 4 illustrates a testing or debugging board 200 in which sits PLD 16. Also included on board 200 are external memory to PLD--SRAM 204 and flash memory 208. Connected to the microprocessor 108 of the PLD may be any of a variety of communication port connectors used to communicate from the board to the outside world. By way of example, shown are a general-purpose parallel I/O port connector 212, a JTAG connector 214 and a USB connector 216. Through any one of these ports communication is enabled to either a test system (used when the PLD is being tested by the manufacturer), or to a host computer (used by a design engineer to debug the PLD). In addition to a test system or host computer issuing control signals and receiving results, it can also download and program the routines needed into memory 106 of the PLD.

¹ Independent claim 20, similar to claims 1, 7, and 13 discussed above, recites "A method of testing a programmable logic device (PLD), said method comprising: manufacturing a PLD that includes programmable logic, an embedded microprocessor and associated memory." Please refer to the discussion relating to claims 1, 7, and 13 regarding the "embedded microprocessor."

Page 11, lines 1 to 6. In step 312 the PLD is placed into the test socket (or other board) and a “configure device for test” procedure is performed. As part of this configuration, the on-chip microprocessor and its associated memory are programmed with the selected test routines. One or many routines may be chosen. The memory holds the selected routine patterns and other test vectors while the microprocessor may be programmed with a control program or control signals.

6. GROUNDS OF REJECTION TO BE REVIEWED ON APPEAL

Ground I:

The rejections presented for review are as follows:

A. The rejections of claims 1-28 under 35 U.S.C. § 102 (e) as being anticipated by U.S. Patent No. 7,020,598 issued to *Jacobson*.

7. ARGUMENT

7.1. Ground I

With respect to Ground I above, the rejected claims are argued as two groups.

7.1.1. Independent Claims 1, 7, 13

***Jacobson* does not teach all of the limitations of each of claims 1-19 and 27-28 (“Group 1”).**

Independent claim 1 specifically requires “a programmable logic device comprising... a hardcoded microprocessor in communication with programmable logic.” In other words, the microprocessor is embedded inside the PLD. Independent claim 7 likewise requires a microprocessor inside the PLD. Independent claim 13 specifically requires “manufacturing a PLD that includes programmable logic, an embedded microprocessor and associated memory.”

Jacobson, however, fails to teach “a PLD that comprises...a hardcoded microprocessor in communication with programmable logic.” To the contrary, *Jacobson* teaches away from these claims when it advocates usage of a diagnostic microcontroller (105) *outside* of the PLD (110). *See FIG. 1. See also, e.g.,*

diagnostic microcontroller 105 and PLDs 210, 215, and 220 of FIG. 2 and FIG. 5. Jacobson advocates usage of the microcontroller of a “self contained product” or electronic device such as a mobile telephone or PDA, “thereby converting it to a remotely diagnosable/reconfigurable product.” *Jacobson Col. 3, lines 60-64. Jacobson* further teaches that the electronic device 100 may also be a larger system such as, for example, a satellite. *Col. 3, line 64 to Col. 4, line 4.*

One of skill in the art would understand and recognize a distinction between usage of a microcontroller or processor of a larger electronic device to perform diagnostic tests of a PLD and embedding a special purpose microcontroller into a PLD. Likewise, conversion of an electronic device so that it may use a process of the device to test a PLD is quite different from "manufacturing a PLD that includes programmable logic, an embedded microprocessor and associated memory" (claim 13) so that the PLD can rapidly test itself.

As mentioned in the present application, by running testing or debugging routines directly on the PLD using an embedded microprocessor, speed improvements from one thousand times up to one million times may be achieved versus the typical testing utilizing a processor outside of the PLD. *Summary, last paragraph.*

Note that such an advantage would not be present in the systems taught by *Jacobson*, where the diagnostic processor is outside of the PLD.

Further, there can be no confusion between an electronic device and a PLD, as *Jacobson* makes an unmistakable distinction between electronic devices and PLD's that may be included as part of an electronic device. *See e.g, Col. 1, lines 36-54.*

The final Office Action takes the position that the microcontroller being within the same packaging as the programmable logic device anticipates the independent claims that require a microprocessor within a programmable logic device. Applicant disagrees that a microcontroller being next to a programmable logic device is the same thing as a microcontroller being inside the programmable logic device.

The final Office Action at the bottom of page 2 also points out that "The technology today allows multiple processors and programmable logic devices within the same packaging as is well known in the art." Applicant does not dispute that *Jacobson* shows a diagnostic microcontroller next to a programmable logic device within a larger electronic device such as a mobile telephone. However, even if, *ad arguendo*, the prior art *at the time of the invention*, included electronic devices with multiple processors, such prior art still does not anticipate or teach embedding a processor into a PLD, as uniquely recited by each of independent claims 1, 7, and 13.

Finally, the Final Office Action points out that *Jacobson*, at Col. 15 lines 49-51 discloses "reconfiguring a programmable logic device within the electronic device to act as the diagnostic microcontroller."

Even if an electronic device such as that shown in FIG. 2 of *Jacobson*, comprises multiple PLDs, and one PLD is used as a diagnostic microcontroller, *Jacobson* still fails to teach the claim 1 limitation of "a programmable logic device that comprises... a hardcoded microprocessor in communication with programmable logic" and the claim 7 limitation of "a programmable logic device (PLD) comprising ...a hard-coded microprocessor ..." and the claim 13 limitation of "manufacturing a PLD that includes programmable logic, an embedded microprocessor and associated memory."

More specifically, even if programmable logic device 210 of FIG. 2 could be reconfigured to function as the diagnostic microcontroller that then would be able to diagnose programmable logic devices 215 and 220, there still would be no microprocessor embedded within one of the programmable logic devices along with programmable logic, memory, a test routine, etc. as required by the varying independent claims.

Furthermore, a programmable logic device is by definition programmable, and not "hard coded" as the claim microprocessor is recited in independent claims 1 and 7.

Since the dependent claims 2-6, 8-12, 14-19, and 27-28 depend from independent claims 1, 7, and 13, it is respectfully submitted that they are each

patentable over the art of record for at least the same reasons as set forth above with respect to the independent claims. Further, each of the dependent claims requires additional features that when considered in light of the claimed combination further distinguishes the claimed invention from the art of record.

7.1.2. Independent Claim 20

***Jacobson* does not teach all of the limitations of each of claims 20-26 (“Group II”).**

Independent claim 20 requires "mounting in a test socket a PLD that includes user logic, an embedded microprocessor and associated memory."

As discussed above, *Jacobson* teaches “converting” an electronic device or self contained product into a remotely diagnosable or reconfigurable product. *See. Col. 3, line 60 to Col. 4, line 4.* There are no teachings within *Jacobson* of mounting the PLD within a test socket, and the Examiner has not presented any rationale why this is taught by *Jacobson*. Further, one of skill in the art would not understand the electronic device 100 of *Jacobson* to include a test socket for a PLD, and would not understand *Jacobson* to teach removal of the PLD from the permanent place it occupies in device 100, to any test socket.

Since the dependent claims 21-26 depend from independent claim 20, it is respectfully submitted that they are each patentable over the art of record for at least the same reasons as set forth above with respect to the independent claims. Further, each of the dependent claims requires additional features that when considered in light of the claimed combination further distinguishes the claimed invention from the art of record.

8. CONCLUSION

In view of the foregoing, all of the claim rejections under 35 U.S.C. § 102 (e) as being anticipated by *Jacobson* cannot stand for at least the reasons discussed. *Jacobson* does not teach all of the limitations of claims of claims 1-19, and 27-28 of Group I and claims 20-26 of Group II.

In view of the foregoing, Appellants respectfully request that the Board reverse the Examiner's rejection of all pending claims. In addition, Appellants believe all claims now pending in this application are in condition for allowance. The issuance of a formal Notice of Allowance at an early date is respectfully requested.

Respectfully submitted,
Weaver Austin Villeneuve & Sampson LLP

/Peter G. Mikhail/

Peter G. Mikhail
Registration No. 46,930

Weaver Austin Villeneuve & Sampson LLP
Attorneys for Appellant

9. CLAIMS APPENDIX

CLAIMS ON APPEAL

1. (Original) A programmable logic device (PLD) comprising:

programmable logic that includes test logic;

a port for external communication;

a hard-coded microprocessor in communication with said programmable logic; and

memory that includes a test routine, said memory being in communication with said microprocessor and said programmable logic, whereby said test logic is tested using said test routine under control of said microprocessor.
2. (Original) A PLD as recited in claim 1 wherein said port is a parallel port, a serial port, a USB port or a JTAG port.
3. (Original) A PLD as recited in claim 1 wherein said memory is part of said programmable logic.
4. (Original) A PLD as recited in claim 1 wherein said memory is part of said microprocessor.
5. (Original) A PLD as recited in claim 1 wherein said microprocessor includes an analysis routine for analyzing results of said test routine.

6. (Original) A PLD as recited in claim 1 wherein said microprocessor includes a control routine for controlling execution of said test routine.
7. (Original) A programmable logic device (PLD) comprising:
- programmable logic that includes user logic;
 - a port for external communication;
 - a hard-coded microprocessor in communication with said programmable logic; and
 - memory that includes a debugging routine, said memory being in communication with said microprocessor and said programmable logic, whereby said user logic is debugged using said debugging routine under control of said microprocessor.
8. (Original) A PLD as recited in claim 7 wherein said port is a parallel port, a serial port, a USB port or a JTAG port.
9. (Original) A PLD as recited in claim 7 wherein said memory is part of said programmable logic.
10. (Original) A PLD as recited in claim 7 wherein said memory is part of said microprocessor.
11. (Original) A PLD as recited in claim 7 wherein said microprocessor includes an analysis routine for analyzing results of said debugging routine.

12. (Original) A PLD as recited in claim 7 wherein said microprocessor includes a control routine for controlling execution of said debugging routine.

13. (Original) A method of testing a programmable logic device (PLD), said method comprising:

manufacturing a PLD that includes programmable logic, an embedded microprocessor and associated memory;

downloading to said memory a test routine;

executing said test routine under control of said microprocessor to test said programmable logic;

storing raw data resulting from execution of said test routine; and

sending results based on said raw data of said test routine from said microprocessor to a test system external to said PLD, whereby said test system determines the functionality of said PLD.

14. (Original) A method as recited in claim 13 further comprising:

downloading to said microprocessor a control routine for controlling execution of said test routine.

15. (Original) A method as recited in claim 13 wherein said results are said raw data.

16. (Original) A method as recited in claim 13 further comprising:
- downloading to said microprocessor an analysis routine for analyzing said raw data from said test routine; and
- executing said analysis routine to produce said results, wherein said results reflect conclusions based on said raw data.
17. (Original) A method as recited in claim 13 further comprising:
- downloading to said microprocessor a compression routine for compressing said raw data from said test routine;
- compressing said raw data; and
- sending said compressed raw data as said results.
18. (Original) A method as recited in claim 13 wherein said associated memory is part of said programmable logic.
19. (Original) A method as recited in claim 13 wherein said associated memory is part of said microprocessor.

20. (Original) A method of debugging a programmable logic device (PLD), said method comprising:

mounting in a test socket a PLD that includes user logic, an embedded microprocessor and associated memory;

downloading to said memory a debugging routine;

executing said debugging routine under control of said microprocessor to debug said user logic;

storing raw data resulting from execution of said debugging routine; and

sending results based on said raw data of said debug routine from said microprocessor to a host computer external to said PLD, whereby said host computer determines the functionality of said PLD.

21. (Original) A method as recited in claim 20 further comprising:

downloading to said microprocessor a control routine for controlling execution of said debugging routine.

22. (Original) A method as recited in claim 20 wherein said results are said raw data.

23. (Original) A method as recited in claim 20 further comprising:

downloading to said microprocessor an analysis routine for analyzing said raw data from said debugging routine; and

executing said analysis routine to produce said results, wherein said results reflect conclusions based on said raw data.

24. (Original) A method as recited in claim 20 further comprising:

downloading to said microprocessor a compression routine for compressing said raw data from said debugging routine;

compressing said raw data; and

sending said compressed raw data as said results.

25. (Original) A method as recited in claim 20 wherein said associated memory is part of said user logic.

26. (Original) A method as recited in claim 20 wherein said associated memory is part of said microprocessor.

27. (previously presented) A programmable logic device as recited in claim 1 wherein said hard-coded microprocessor is embedded within said programmable logic device.

28. (previously presented) A programmable logic device as recited in claim 7 wherein said hard-coded microprocessor is embedded within said programmable logic device.

10. EVIDENCE APPENDIX

No evidence has been submitted pursuant to §§ 1.130, 1.131, or 1.132 of 37 CFR, nor has any other evidence been entered by the examiner.

11. RELATED PROCEEDINGS APPENDIX

There have been no decisions rendered by a court or the Board in any proceeding identified pursuant to paragraph (c)(1)(ii) of 37 CFR 41.37(c)(1).